TAG Derivation as Monotonic C-Command*

Robert Frank
Dept. of Cognitive Science
Johns Hopkins University
rfrank@cogsci.jhu.edu

K. Vijay-Shanker
Dept. of Computer and Information Sciences
University of Delaware
vijay@cis.udel.edu

The TAG adjunction operation operates by splitting a tree at one node, which we will call the adjunction site. In the resulting structure, the subtrees above and below the adjunction site are separated by, and connected with, the auxiliary tree used in the composition. As the adjunction site is thus split into two nodes, with a copy in each subtree, a natural way of formalizing the adjunction operation posits that each potential adjunction site is in fact represented by two distinct nodes. In the FTAG formalism (Vijay-Shanker, 1988) each potential adjunction site is associated with two feature structures, one for each copy. As an alternative to this operationally defined rewriting view of adjunction, Vijay-Shanker (1992) suggests that TAG derivations instead be viewed as a monotonic growth of structural assertions that characterize the structures being composed. This proposal rests crucially on the assumption that the elementary trees are characterized in terms of a domination relation among nodes, and that each potential adjunction site is represented by two nodes standing in a domination relation. Under this proposal, the structures α and β in Figure 1 would be used to derive long-distance wh-movement. To adjoin β into α, the root and foot nodes of β are identified with the two C′ nodes standing in a domination relation in α (represented by the dotted line). This domination relation still holds after adjunction, as do all the other domination relations stated in defining α and β. (In sentences in which there is no adjoining at the C′ node, e.g., 'I wonder what Mary saw,' these C' nodes could collapse, preserving domination under the assumption that it is a reflexive relation.) Domination has also been argued to play a role in multi-component structures, where there is assumed to be a domination relationship between a frontier node of one component and the root of the other.

While the use of domination relationships is attractive in allowing us to view TAG derivations as monotonic additions to a set of domination relations, the linguistic motivation for such domination statements among duplicated nodes is not very clear. Instead, from the point of view of the grammar, what seems to be crucial in defining the relevant portion of the structure of α is not that there should be two C′ nodes standing in a domination relation, but rather that the moved element 'what' must stand in a certain structural relation with its trace, namely c-command, both in the the elementary tree and throughout the derivation. Given the way in which adjunction is defined and the manner in which domination statements have been utilized, it turns out that this c-command relation is always preserved by the application of adjunction. In this work, we take this preservation of c-command under adjunction to be the central property of the operation, and not a residual effect of some specific use of dominance relations and their interaction with adjunction. Thus, what was previously seen as the central preservation of dominance relations will turn out to arise as a side effect of the preservation of c-command relations on our proposal. This leads us to postulate that TAG elementary structures are defined in terms of their c-command relations, and that TAG derivations constitute monotonic additions to a set of c-command relations. That is, instead of viewing TAG structures being defined in terms of domination relations, we consider any domination relations that will be preserved to arise or be inferred from the c-command relations used in defining TAG structures.

In characterizing TAG elementary trees, we make use of independently motivated assumptions concerning the c-command relations that exist among structural elements. Thus, we assume that the c-command relations within elementary trees will be determined by (at least) the following principles (cf. the definitions in Kayne (1994)):[1]

(1)a. A moved element c-commands its trace.
b. A head and its complement c-command one an-

*Thanks to Tony Kroch, Seth Kulick, and two anonymous reviewers for helpful comments and discussion. We gratefully acknowledge the financial support of NSF grants SBR-97-10247 and SBR-97-10411.

[1]We leave for the moment the question of the relationship between specifiers and the X′ projections they specify.

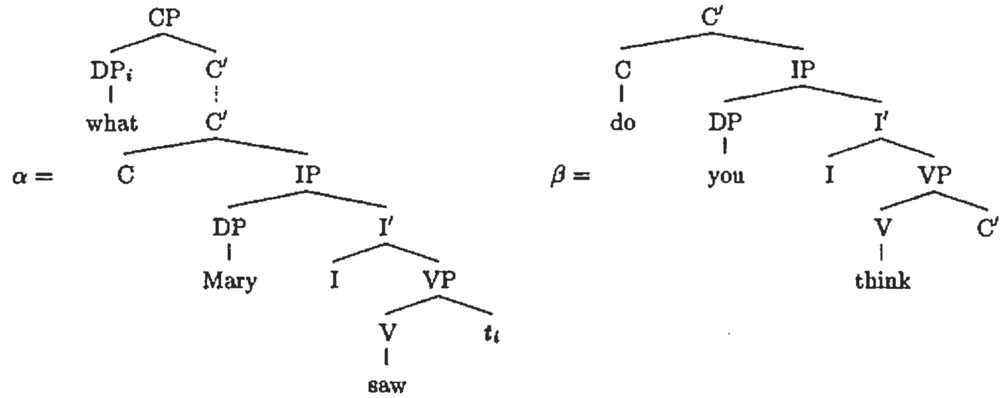

Figure 1: Preservation of Domination in TAG Derivation

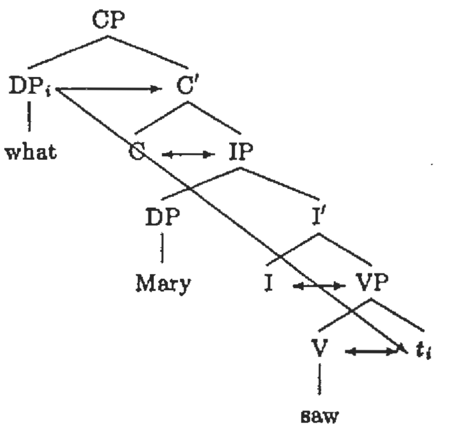

Figure 2: Defining elementary trees with c-command

other.

c. A modifier c-commands the phrase it modifies.

Following these principles leads us to the structure in Figure 2 for the elementary tree α from Figure 1 (where arrows indicate c-command relations).[2] There are two crucial c-command relations to observe in this structure: the first between the fronted wh-phrase and its trace, and the second between the wh-phrase and the C′ node, which serves as the target of movement within the elementary tree. Let us suppose that derivations proceed as monotonic combinations of structures like this one defined in terms of c-command. This means that we can perform an operation analogous to adjunction, inserting a structure like β in Figure 1 between the fronted wh-element and the C′, by identifying this C′ with the foot node of the auxiliary structure. In the structure that results, all of the c-command relations stated in the elementary trees are preserved, most notably those between the fronted wh-element and both the C′ and its trace. From this perspective, we can now understand why it was necessary in the framework of Vijay-Shanker (1992) to posit a domination relation between the two C′ nodes in α in Figure 1: as an indirect representation of (at least) the principle requiring that moved elements c-command their traces.

This proposal allows us to explain many previously stipulated properties of TAG elementary trees and constraints on the adjunction operation. Consider, first of all, the structural differences between two classes of auxiliary trees noted by Kroch (1989) and Schabes and Shieber (1994): *complement* auxiliary trees on the one hand and *modifier* or *athematic* auxiliaries on the other. Recall that modifier auxiliaries have the distinctive property that their foot node is the sister of a modifying phrase and is the daughter of the root node. Following the principles in (1), it follows that the foot of a modifier auxiliary will c-command its XP sister, i.e., the adjunction site, though not vice versa. In contrast, the foot node of a complement auxiliary must be the sister of some head of which it is a complement. Thus, this foot node will both c-command and be c-commanded by its sister node. From this structural difference, we can derive certain contrasts in the use of these classes of auxiliaries during TAG derivations. Since modifier auxiliary trees introduce an asymmetrical c-command relation with their foot node, it follows that their adjunction will not disrupt any c-command relations that the modified phrase already enters into. Thus, it follows the adjunction of mod-

[2]The linkages of direct domination in Figure 2 are not intended as part of the representation, but rather as aid to the reader in comparing our proposed structure to that standardly assumed. Note that certain implicit c-command relations, such as that between C and the subconstituents of IP are suppressed in this figure, but we assume that they are present. See Frank and Vijay-Shanker (1998) for extensive discussion of the properties of structures defined in terms of c-command and the relationship between such structures and those defined in terms of dominance.

ifier auxiliaries should be quite free and indeed may occur at any node in an elementary tree. In fact, if the root and foot of the auxiliary tree are considered segments of the same category (which explains the asymmetrical c-command relation between the modifier and modifiee), this would explain the possibility of multiple adjunction by modifier auxiliary trees at a single node considered by Shieber and Schabes. On the other hand, it has sometime been stipulated that adjunction of predicative auxiliaries is blocked at the foot node of predicative auxiliary trees. As just noted, since the foot of a predicative auxiliary is a complement, this node c-commands the lexical head of the auxiliary. Adjoining to this foot node by another predicative auxiliary tree will have the effect of lowering it, so that it no longer c-commands the head. This would violate the monotonicity requirement on c-command relations during the derivation, and we could therefore reduce the stipulation often used in TAG to a more general condition on monotonicity. In contrast, adjunction at the foot node of a modifier auxiliary will not be ruled out, as the modification relation does not entail mutual c-command, and such lowering of the foot does not force the retraction of any c-command relations.

Now that we have seen that complement auxiliary trees may not adjoin at a complement node, the obvious question is where they may adjoin. Clearly, adjoining at the root of a structure would not require any statements of c-command relations to be retracted, and thus is permissible. But this is not an interesting situation as it can also be considered to be substitution. Saying that this derivation step is a case of adjunction is merely an artifact of the TAG formalism which, quite possibly, has no significant implications. The interesting cases correspond to adjoining complement auxiliary trees to internal nodes (i.e., non-root nodes). Suppose that we follow Kayne's (1994) suggestion that specifier positions should be assimilated to adjuncts, specifically with respect to their c-command relations (i.e., they c-command but are not c-commanded by their X′ sister).[3] This will mean that we must add the following additional principle of elementary tree formation to those in (1):

(2) A specifier c-commands the phrase to which it attaches.

¿From this, we are able to derive the result that the only internal (non-root) nodes where predicative auxiliary trees can adjoin are X′ nodes that are sister to a specifier. The reason for this is exactly as

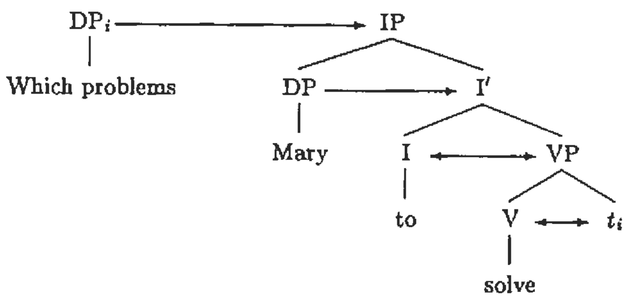

Figure 3: Extraction from IP

in our discussion of the tree in Figure 2, namely that it is only in the context of unidirectional c-command from the specifier to the X′ node that it is possible to insert a complement auxiliary that will have the effect of lowering the X′ node. Interestingly, this view matches quite well what has been assumed in previous TAG analyses, where successive cyclic A′-movement is accomplished by adjunction at C′ as discussed earlier, and successive cyclic A-movement by adjunction at I′. Indeed, we believe that this proposal provides a means of explaining why unbounded movement uniformly proceeds through specifier positions.

One potentially problematic case of complement adjunction at an internal XP node involves wh-extraction from an ECM verb as in an example like 'Which problems (do) you expect Mary to solve?' The most straightforward TAG analysis of such a case would adjoin an IP auxiliary tree representing the matrix clause, i.e., *you expect IP* into a CP initial tree representing the embedded clause from which extraction has taken place, i.e., *which problems Mary to solve*. It is possible, however, that this extraction involves a more complex multi-component derivation. Thus, the representation of the embedded clause may not include a CP projection at all, but rather could perhaps simply represent the fronted wh-element as c-commanding the IP node, as in Figure 3. This c-command relation would be preserved if the embedded IP substituted into the complement position of a CP-rooted matrix tree and the wh-phrase substituted into the specifier of CP position of the same tree.[4,5] This kind of multi-component tree set, in which there is no dominance link between

[3] This raises the interesting possibility that specifiers could be adjoined in the TAG sense as well. Although this would have certain benefits with respect to the treatment of subject islands, we believe at present that it is not immediately compatible with our proposal to derive the possible loci of adjunction from c-command monotonicity.

[4] It should be noted that this version of adjoining does not remove the restrictive character of adjoining that is crucial in deriving island effects. It is in fact fairly straigbtforward to provide a simple view of possible elementary tree domains, analogous to the CETM of Frank (1992), so that the standard effects are derived.

[5] Other analyses of this case are, of course, possible, some reminiscent of ideas presented in a TAG framework by Rambow and Kroch (1994), in which ECM is taken to involve raising to a specifier position of a higher clause. Space presents us from exploring this alternative here.

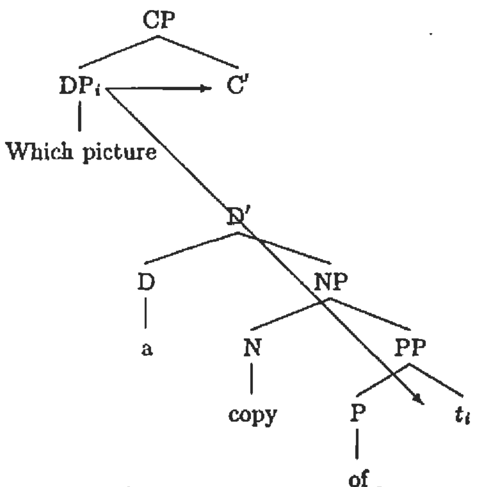

Figure 4: Extraction from NP

the two components, but instead a c-command link, has in fact been exploited in previous TAG analyses of wh-movement (Frank, 1992). Under our proposal, dominance links as they have been exploited in multi-component sets can effectively be replaced by c-command links, as these more effectively convey the grammatically relevant structural relations. Moreover, our proposal allows us to understand why no dominance links were previously posited between certain components of a multi-component set: there is no relevant structural relation linking them, so their hierarchical order is free.

It is a well-known that extraction from NP must be handled in a different fashion in TAG from extraction from clausal complements, as the adjoining operation allows only the insertion of recursive structure. However, using c-command to define the elementary structures allows us to generalize the adjoining operation so as to capture both cases. Specifically, a derivation of a sentence like 'Which picture did you buy a copy of?', could proceed by inserting a non-recursive structure, with root C' and foot D' between the two components of the set in Figure 4.[6] What would previously have been assumed to be a domination relation between the C' node and the D' node now can be seen to follow from the c-command relation between the moved element and the trace. In the derived structure, this c-command relation, and therefore as a side effect the domination relation, continues to hold. Note that our hypothesis that c-command relations should be preserved during derivation would rule out a possible TAG analysis where the structure for *a copy of* is considered to be an auxiliary tree. Adjunction of such an auxiliary tree would violate the requirement of preservation of c-command as it would have to be adjoined at the complement NP node of the verb *buy*.

Finally, we suggest that our recasting of TAG derivations as manipulations of c-command relations leads to a resolution of thorny issues for the TAG framework posed by examples such as 'Does Gabriel appear to like gnocchi?'. The relevant property of this example and others like it (e.g., involving clitic climbing) is that the lexical material associated with the matrix clause (i.e., *does* and *appear*) is intermingled with that of the embedded clause in such a way that there is no natural way of localizing it in a single auxiliary tree. Consequently, this example seems to require a derivation that is considerably more complex than a simple instances of raising. Supposing instead that the elementary tree headed by *appear* consists of the usual I' raising auxiliary (stated in c-command terms) together with the verb *does* which is stated to c-command the root I', as a result of its having raised, in a spirit similar to the structure in 3, but applied to head movement. When this auxiliary combines with the subordinate clause elementary tree, *does* is free to float above the subject, as this will preserve the c-command relation.[7]

[6]The derivation shares a good deal in common with the proposal of Kulick (this volume). Detailed comparison of these two analyses awaits future work.

References

Frank, R. 1992. *Syntactic Locality and Tree Adjoining Grammar: Grammatical, Acquisition and Processing Perspectives.* Ph.D. thesis, University of Pennsylvania, Philadelphia, PA.

Frank, R. and K. Vijay-Shanker. 1998. Primitive c-command. Manuscript, Johns Hopkins University and University of Delaware.

Kayne, R. 1994. *The Antisymmetry of Syntax.* MIT Press, Cambridge, MA.

Kroch, A. 1989. Asymmetries in long distance extraction in a tree adjoining grammar. In M. Baltin and A. Kroch, editors, *Alternative Conceptions of Phrase Structure.* University of Chicago Press, Chicago, IL, pages 66–98.

Schabes, Y. and S. Shieber. 1994. An alternative conception of tree adjoining derivation. *Computational Linguistics*, 20:91–124.

Vijay-Shanker, K. 1988. Feature-structure based tree-adjoining grammars. In *Proceedings of the 12th International Conference on Computational Linguistics*, Budapest.

Vijay-Shanker, K. 1992. Using descriptions of trees in a tree adjoining grammar. *Computational Linguistics*, 18:481–518.

[7]Of course, it is also possible for *does* to remain below the subject, deriving 'Gabriel does appear to like gnocchi.' It is unclear to us at present whether this is a problem, and if it is, what the nature of the solution would be.